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DISCLAIMER

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Update of Environmental and Safety Analyses for the National Ignition Facility: Using a New Model to Track Target Material Usage

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I Introduction

The purpose of this paper is to report the methodology and assumptions, data, and results of calculations concerning safety and environmental issues related to excursions to currently planned NIF operations. Many possible uses of NIF have been suggested over the years. While some of these possible uses have been adopted into the baseline plans for NIF, many others have not. While we do not yet know all of the possible approved uses for NIF, one of the items that would bear on whether a certain course use might be adopted or not would be its environmental and safety impact. Here we examine certain excursions from the existing planned operations to determine their environmental and safety impacts. These excursions are related to the use of 'cocktail' hohlraums as the baseline target for ignition experiments in the National Ignition Facility (NIF) as well as a possible increased utilization of beryllium and uranium. This paper also addresses the fission products produced from cocktail hohlraum use for high yield experiments. Again, this analyses does not imply an authorization to proceed with such modes of operation, or any intent to proceed beyond this analyses.

A detailed analysis of a range of postulated experiments for NIF was conducted for the years 2003 through 2011. The goal was to quantify the amount of target material introduced into the target bay per year. The assumptions outlined in this paper are based on the worst-case scenario from an environmental perspective.

A spreadsheet was developed to integrate all the gathered information and to calculate the total amount of materials per year. The spreadsheet was also designed as a tool for future analyses. The total amount of material was used to justify and establish a proposed upper bound for the amount of beryllium and uranium introduced into the target bay in a given year.

The cocktail hohlraum and associated appendages were modeled with the neutron transport code TART98 to determine neutron fluxes within the target bay. To determine the activation and fission products from a maximum possible shot of 45 MJ, the TART output was entered into ACAB98.

Isotopes that are potentially most detrimental to the environment were selected from the activation and fission products calculated by ACAB. With these key isotopes, routine and beyond design basis accident scenarios were run in CAP-88 and GENII respectively to determine the applicable doses for the population and at the site boundary.

From this analysis, it is concluded that the introduction of cocktail hohlraums as the base target type in high yield experiments does not increase the current safety and environmental analysis dose levels.

II Amount of Material by Year

A flexible, linked spreadsheet was created to sum the total amount of material by year for planned experiments from 2003 to 2011. During this analysis, a component approach to identifying experiments was used to provide maximum extendibility for future use of the spreadsheet. A five-step process was used to quantify the amount and type of material introduced into the target bay by year. During every step, bounding or worst-case scenario assumptions with respect to the environment were made.

The first step was to integrate the number and type of requested shots with the projected number of available shots for each year. During this step, the number of shots per class of experiment were also put into the spreadsheet. A target type was then matched to each class of experiment. The next step was to quantify the worst-case dimensions for each target component and to subsequently calculate the volume of material present. Materials most hazardous to the environment were then selected for each target component for simplicity and to establish an upper bound on uranium and beryllium. Finally, a spreadsheet was used to calculate the total material per year. An example to illustrate this process is outlined in the sections that follow.

A Step 1 - Number of Shots per Year and Class of Experiment

The number of shots requested were matched with the number of projected available shots for each year. Brian MacGowan provided information that reflects the requested number of shots with respect to time.[1] He also provided a worksheet which gives the number of available shots per year.[2] This document reports the projected number of shots available as the facility is completed from first cluster to full NIF. The information from these two documents was entered into the spreadsheet. Operational test procedure (OTP) shots are not included in this model.

Dan Kalantar provided assumptions pertaining to the classes of experiments and number of shots for the early years (2003-2005).[3] These experiments are not reflected in the documents obtained from Mac Gowan. Many of the early experiments will be used to verify laser functions and beam timing, develop/debug diagnostics, and for early target development.

Based on the information provided by Mac Gowan, year 2007 is currently oversubscribed by 85 shots (i.e. more shots are requested than are available). The NIF Shot Committee will make a more detailed schedule of experiments for NIF to rectify this problem. For the purposes of this analysis, some of the shots requested for fiscal year 2007 were moved to adjacent years. Table 1 outlines these assumptions.

Experiment	Number of Shots	Moved to Year
Ignition Campaign Halfraum exp	18	2006
Continuing melt/refreeze exp (64 beams)	6	2008
64-Beam integrated exp	10	2008
64-Beam non-ideal implosions	10	2008
Exps preliminary to strength (80 beams)	7	2008
Exps preliminary to opacity (80 beams)	7	2008
Continuing non-ideal implosions (96 beams)	7	2008
96-Beam cylindrical implosions	10	2008
96-beam convergent hydro	10	2008

Table 1 Shots Moved from 2007

Projected early yield shots and tritium target development were summarized by Mike Tobin.[4] In this model, it is assumed that no time is lost due to target chamber radioactivity for yield shots that are less than 1 MJ. During 2010 and 2011 numerous yield shots were requested to complete ignition campaigns and uranium equation-of-state experiments. Brian Mac Gowan provided assumptions and calculations for the lost shots due to target bay contamination after a given yield shot.[5] Yield shots with an energy of 1 MJ and higher have an associated equivalent shot value. MacGowan further assumed that yield shots would be conducted to take advantage of the weekend and that a maintenance day after each shot was necessary. Table 2 summarizes the information pertaining to target bay stay-out times for high yield shots.

Yield	Stay-out Days	Lost Days	Lost Shots
1 MJ	2.4	0.4	1.8
2 MJ	3	1	4.5
5 MJ	3.8	1.8	8.1
10 MJ	4.4	2.4	10.8
20 MJ	5	3	13.5

Table 2 Yield Shot Assumptions

Some of the years outlined in this model are currently under-subscribed (i.e. have more shots available than requested). These undefined shots account for collaboration with outside agencies shots as well as shots not yet requested by other NIF users. In terms of materials present, these undefined shots are assumed to have the same type and relative amounts of materials as are present in the requested shots. Appendix A provides the number of shots for each class of experiment by year.

This model accounts for over 100 different classes of experiments planned for NIF. As an example, one class of target, pre-ignition campaign (high fluence), is shown in Table 3. For simplicity, it is assumed that all 65 shots from this class of experiment are the same target type.

Year	**2009**
Experiment	Total
Pre-ignition campaign (high fluence)	65

Table 3 Example - Shots per Class of Experiment

B Step 2 - Identify Target Type for Requested Shots

A wide variety of target types and sizes are planned for NIF use; a complete list of the targets that will be used was not possible for this analysis. Target designers are, however, proposing targets that have similar shapes and features. To ensure flexibility as well as incorporate a large number of different target types in this model, a component approach was developed to identify targets. This system identifies targets with a base shape, scale size, and attached appendages. There are 12 different base shapes and 14 appendages included in this model.

Nino Landen and Dan Kalantar associated target types with each individual class of experiments.[6] For some classes of experiments, two different target types were identified. The targets were also appropriately scaled for each experiment. Appendix B gives the classes of experiments with the assumed target type for each.

Continuing the use of the pre-ignition campaign (high fluence) as an example, Table 4 depicts the fixed target type for this class of experiment. In Table 4: CHohl -

cryo-hohlraum, a - back lighter, b1 - rectangular shield, c - diagnostics and d1 - capsule. Appendix B provides a complete list of the base shapes and appendages with associated abbreviations used in this model.

Experiment	Base	Scale	Appendages
Pre-ignition campaign (high fluence)	CHohl	1	a, b1, c, d1

Table 4 Example - Target Type for Pre-ignition Campaign

C Step 3 - Set Dimensions for each Target Components

After target bases and appendages were identified, assumptions were made to set the volume for each target component was calculated. Kalantar and Dave Eder provided initial estimates for the dimensions for each target component.[7] The dimensions of each target base and appendage were estimated considering the worst-case scenario. Appendix C reports these dimensions and volumes. As an example, the cryo hohlraum dimensions are provided in Table 5.

	Cryo
Description	Cryo-Hohlraum - (CHohl)
Hohlraum	
thickness (cm)	3.500E-03
length (cm)	1.000E+00
Outer diam (cm)	6.000E-01
Inner diam (cm)	3.000E-01
volume (cc)	8.082E-03
Cooling rings	
inside diam (cm)	7.000E-01
outside diam (cm)	9.000E-01
thickness (cm)	1.500E-01
volume (cc)	7.540E-02
Sapphire rods	
diameter (cm)	5.000E-02
length (cm)	1.000E+01
volume (cc)	3.927E-02

Table 5 Example - Cryo-Hohlraum Dimensions

Steve Haan provided the worst-case estimate for the yield capsule.[8] Table 6 gives the dimensions of this capsule. It was assumed that the capsule was equimolar deuterium/tritium and that the shell is beryllium. Fill assumptions include: 400 atm, 293K and the fill amount in the capsule is the same after cryogenic freezing. The ideal gas law was used to approximate the amount of tritium in the yield capsule. The ideal gas law is:

$$PV = nRT$$

where P is the pressure, V is volume, n is the number of moles, R is the gas constant, and T is temperature. Substituting assumed values we have

$$n = 6.97E\text{-}05 \text{ mol}$$

this value yields the tritium mass to be 0.21 mg which equates to ~ 2 Ci. It was further assumed that twice as much tritium remained in the system due to fill procedures. Therefore, a total of 4 Ci was estimated to be the worst-case amount of tritium in the yield capsule. To further bound the estimate for the amount of tritium introduced into the target bay, this capsule was used for all shots containing DT capsules from 2009 to 2011 .

	Appendage d1Y
Description	Capsule - Yield
inner Diam (cm)	2.000E-01
Outer Diam (cm)	2.160E-01
Volume (cc)	1.088E-03
Fill (DT Ice)	
Diameter (cm)	2.000E-01
Volume (cc)	4.189E-03

Table 6 Worst-case Yield Capsule

D Step 4 - Select Material for each Target Component

Materials may differ for each individual shot. For the purposes of this analysis, the material of each target piece was fixed for simplicity and to establish an upper bound for uranium and beryllium. Again, materials were chosen that are worst-case in terms of environmental impact. The material assumptions were provided by Kalantar.[9] Larry Suter provided the worst-case estimate for the cocktail materials (60% U(depleted), 20%Dy, 20%Au) used in ignition targets.[10] Appendix D gives the materials assumptions made for each target segment. Table 7 delineates the assumptions for the pre-ignition campaign (high fluence) example.

Description		**Assumption**
Cryo Hohlraum	CHohl	Assumes Cocktail* w/Cu rings, Sapphire rods
Backlighter	a	Assumes Ta substrate, Iron foil, Cu pole
Rectangular Shield	b1	Assumes Ta Shield coated w/CH
Diagnostic - Camera Shield	c	Assumes Fe base with Be
Capsule	d1	Assumes Be w/D 400 atm, 293K
* Cocktail = 60% U, 20% Dy, 20% Au (atomic weight percent)		

Table 7 Example Target Material Assumptions for Pre-ignition Campaign

E Step 5 - Calculate the Total Material per Year

All of the information gathered in this analysis was entered into a linked target database spreadsheet. A pivot table was then generated to determine the total amount of each type of material per year. This data was then used to generate graphs depicting expected material use per year. Craig Schoendienst was instrumental in linking the data in the spreadsheet to make it a useful tool for future use.[11] The amount of material by year is presented in Appendix E.

This target database spreadsheet was developed as a tool to predict and monitor the total material entering the target bay. The user need only change the target type, geometry, scale, and/or material types to recalculate the total amount of material. Classes of experiments may also be introduced with applicable target types. The pivot table allows the user to sum the material by year or by individual class of experiment. To complete the example outlined above, Table 8 provides the sum of the material for the 65 shots associated with the pre-ignition campaign (high fluence) class of experiment.

Experiment	Pre-Ignition Campaign (high fluence)	
	Year	2009
Material (mg)		
Al		4.064E+03
Au		1.865E+03
Be		3.669E+02
CH		1.569E+01
Cu		4.506E+04
Dy		6.790E+02
Fe		6.512E+02
O		6.095E+03
Ta		1.072E+03
U		6.526E+03
Deuterium		1.812E+01

Table 8 Example Pre-ignition Campaign Total Materials

III Consequences of the use of Cocktail Hohlraums

As a result of the analysis outlined above, it may be necessary to increase the established estimates for the amount of uranium and beryllium to be introduced into the target bay in a single year. The analysis also shows that the thresholds already established for maximum tritium use and neutron emissions per year are adequate. Each of these consequences are discussed in detail in the sections that follow.

Environmental and safety ramifications of the use of uranium in high yield experiments and the subsequent production of fission products are outlined in Section IV.

A Threshold - Maximum Amount of Uranium in NIF

Based on the analysis conducted, the amount of uranium estimated for use per year is larger than previously estimated. This increase is attributed to the proposed use of cocktail hohlraums as a baseline target type for ignition experiments. Using a logarithmic scale on the vertical axis, Figure 1 graphically depicts the projected use of uranium per year. The amount of uranium which will be exposed to 10^{15} or more neutrons is also reflected in the figure.

The results from this analysis indicate that it may be necessary to increase the maximum allowable amount of uranium introduced into the target bay in a given year. To create an envelope that will provide an upper bound for beyond 2011, a 100 g maximum amount is proposed. This amount was determined by scaling all ignition targets to 2.5 NIF and rounding up from a resulting maximum of 85 g.

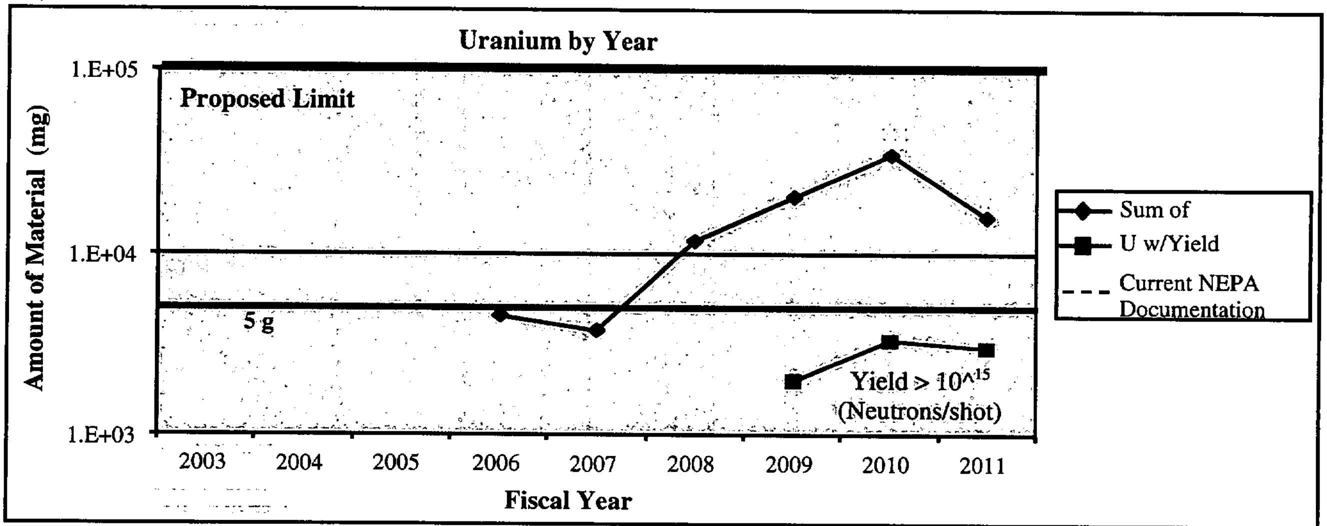


Figure 1 Projected Amount of Uranium per Year

The use of uranium in yield shots and the subsequent production of fission products is also a change from current documentation. Analysis pertaining to the presence of fission products in the target bay is presented in section IV of this paper. In this analysis, it was determined that the fission products gained from a 45 MJ yield shot result in a minimal impact on the environment. Again to provide an upper bound for the number of fissions per year beyond 2011, a number of 1×10^{17} fissions per year is proposed. This amount of fissions equated to a hundred 20 MJ shots in one year.

B Threshold - Maximum Amount of Beryllium in NIF

New estimates for total amount of material show that beryllium is another hazardous material that may required an increase in estimated future use (Figure 2). As a conservative estimate, a total of 100 μm of beryllium ablation was assumed per shot. This was calculated assuming an average of two cameras at 20 cm away from the target with an average of 50 μm of ablation from each. This amount of material was doubled when higher yield shots are expected during 2010 and 2011.

Previous documentation suggested that the total amount of beryllium estimated to be in the target chamber at any time is 25.1 g. This document goes on to project that the only amount of this material that is at risk for release is 1.6 g which is attributed to actual target material that is vaporized during a shot.[12] The analysis presented here assumes beryllium use for all capsules as well as for shock tubes which were not included in previous estimates. It also includes ablated material from diagnostics stated above. Finally, it is assumed that all the target material is vaporized during the shot. The maximum amount of beryllium projected as an environmental concern for a given year is

6 grams. To create an envelope that will provide an upper bound for beyond 2011, a 10 g maximum amount is proposed. This amount was determined by scaling all ignition targets to 2.5, doubling the ablation estimates from diagnostics and rounding up from the resulting maximum of 7.4 g

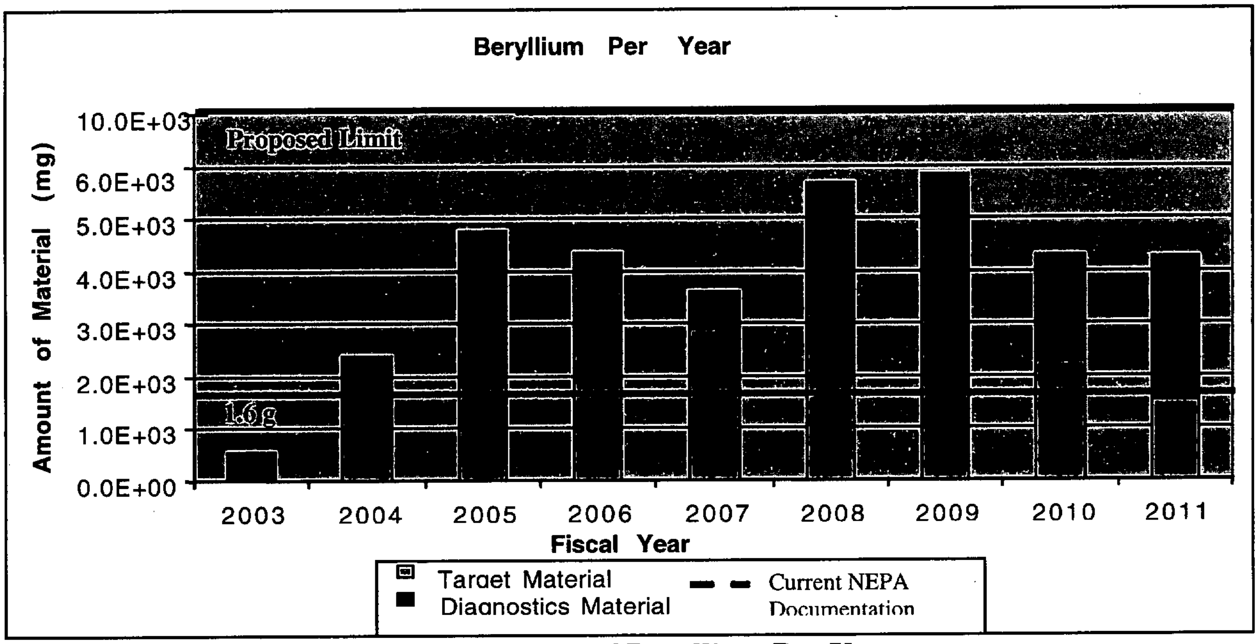


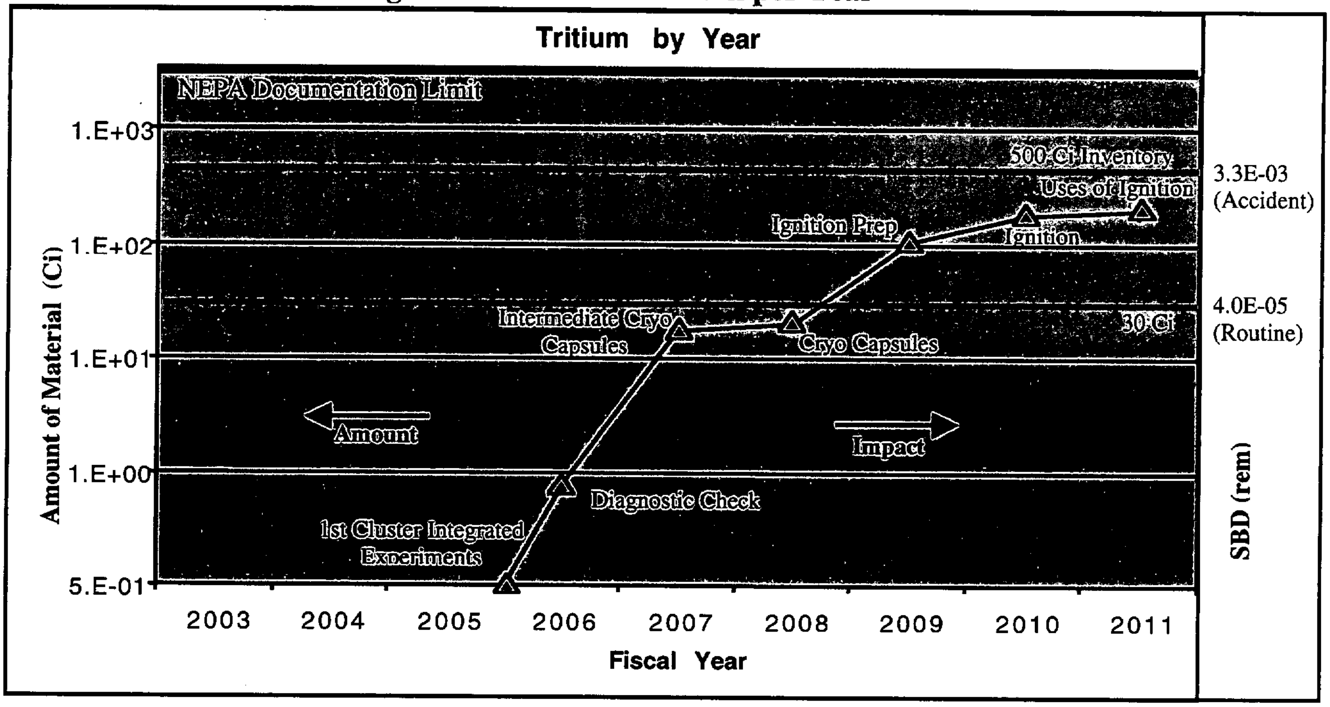
Figure 2 Projected Amount of Beryllium Per Year

C Threshold - Maximum Amount of Tritium in NIF

The projected amount of tritium introduced into the target bay is well below the threshold value established by current NEPA documentation. Original estimates projected a maximum of 1.5 Ci in capsules for indirect drive targets. Even though this analysis estimates up to 4 Ci of tritium in the worst-case capsule, the cumulative totals remain below the maximum allowable levels for tritium use. For a direct drive target, the current estimate is 15 Ci of tritium per target. Direct drive target analysis is not included in the model presented in this paper.

The current EIS establishes a threshold of 1750 Ci of tritium throughput per year. Tritium levels are depicted in Figure 3 for 2003 to 2011. A further requirement for maintaining a facility inventory of tritium at less than 500 Ci is also reflected in current documentation and must be monitored once tritium use begins. Based on the data collected and this models results, the maximum throughput amount expected in the target bay for any year is ~ 300 Ci. The Site Boundary Dose (SBD) which equates to a routine release of 30 Ci in a year and an accidental release of 500 Ci are also shown in Figure 3.

Figure 3 Amount of Tritium per Year



D Threshold - Maximum Neutron Emission per Year

The projected number of neutron emissions in the target bay from yield shots is also below the threshold value established by the current EIS. Original estimates and current documentation established a 1200 MJ yield a year maximum. This amount of yield equates to a threshold of 4.2 E+20 neutrons per year. Figure 4 graphically depicts the projected neutron emissions.. This model does not include neutrons from deuterium capsules which were considered insignificant compared to the number from DT capsules.

IV Environmental and Safety Analysis

The activation and fission products from the use of cocktail hohlraums were calculated for two bounding scenarios. First it was assumed that all the material introduced into the chamber from 2003 to 2011 was deposited uniformly on the inner wall of the target bay. This scenario is bounding but unrealistic since the target bay inner wall will be cleaned biannually. With this material on the inner wall, it was further assumed that 1200 MJ of yield shots were fired for 10 consecutive years. The activation products from this scenario were found to be insignificant compared to the second situation.

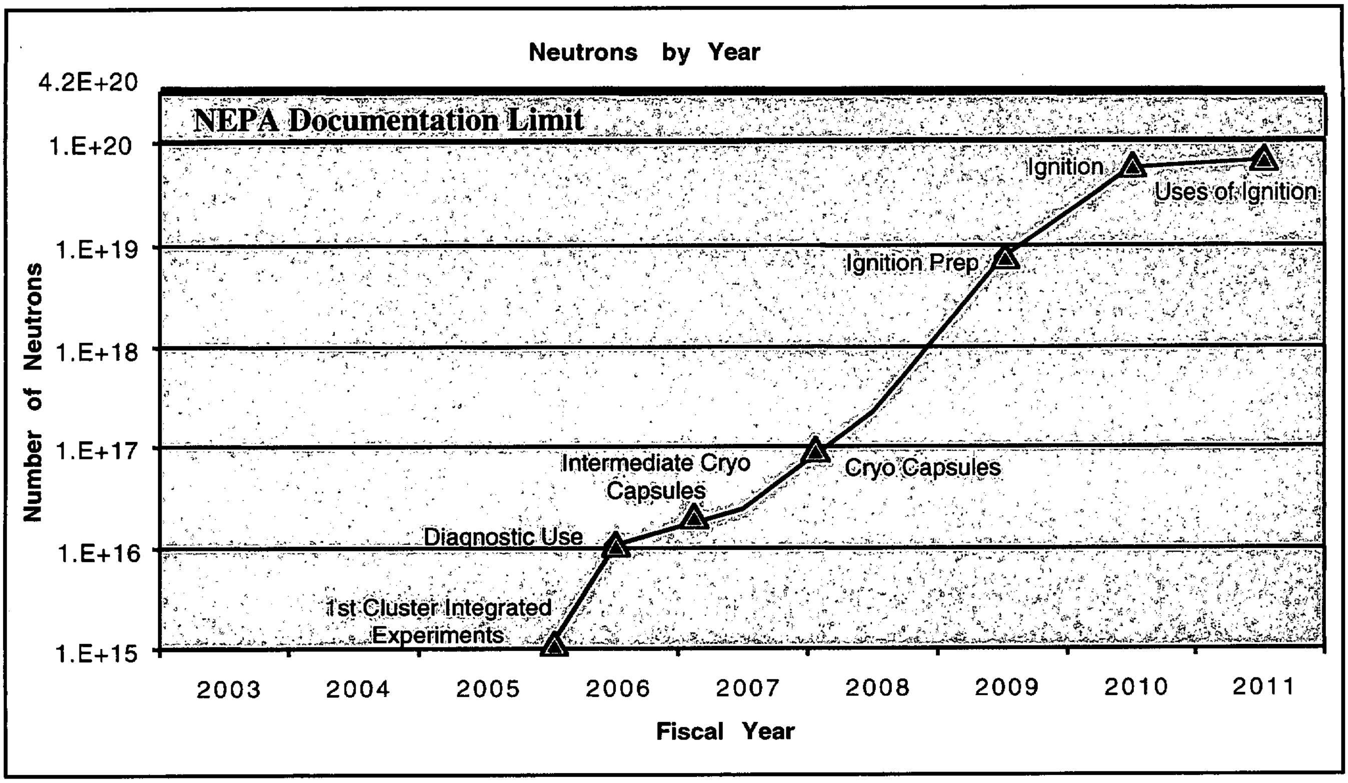


Figure 4 Neutron Emission per Year

The second bounding scenario entails that the cryo-hohlraum target assembly is present during a 45 MJ yield shot with an accident occurring immediately after the shot. The cryo-hohlraum target assembly had to be modeled and run using the neutron transport code TART98[13] to determine the neutron fluxes for the target bay. The output TART file was subsequently used as the input file for ACAB98[14]. ACAB was used to determine the inventories of fission and activation products. To account for the decay and growth of isotopes, a decay output time interval of ten days was used. Jeff Latkowski provided the initial TART files and technical guidance on both bounding scenarios and the use of both codes.[15] Susana Reyes ran both TART and ACAB.[16]

A Key Isotope Selection

ACAB calculated over 700 activation and fission products. For simplicity and to identify which isotopes are potentially hazardous to the environment, a selection process was conducted. From the full list of isotopes, all of the gases and iodine isotopes were selected. The remainder of the list of isotopes was initially screened against two criteria: maximum inventory (including parents/daughters) > 100 μCi and half life > 60 seconds. Based on previous environmental and safety analysis, isotopes with a maximum inventory of less than 100 μCi add an insignificant amount of activity to the total dose.[17] It was further estimated that it would take a minimum of 60 seconds to release particulate to the environment. Based on these criteria, an initial list of 166 isotopes was selected.

To select the key isotopes that are hazardous to the environment, this initial list was then compared to 10 CFR 835[18] and 10 CFR 20.[19] A final list of 61 isotopes were selected to be included in this analysis.

Instead of assuming that an accident occurs at a given time, a bounding case using the maximum inventories of each isotope over a ten day decay period was assumed for this analysis. This case is unrealistic since the maximum inventories of the fission products cannot possibly exist at a given instant in time. However, by assuming the maximum of each key isotope, the upper bound of the maximum possible dose at any time is established. Figure 5 depicts an example of the growth and decay of a nuclide chain.

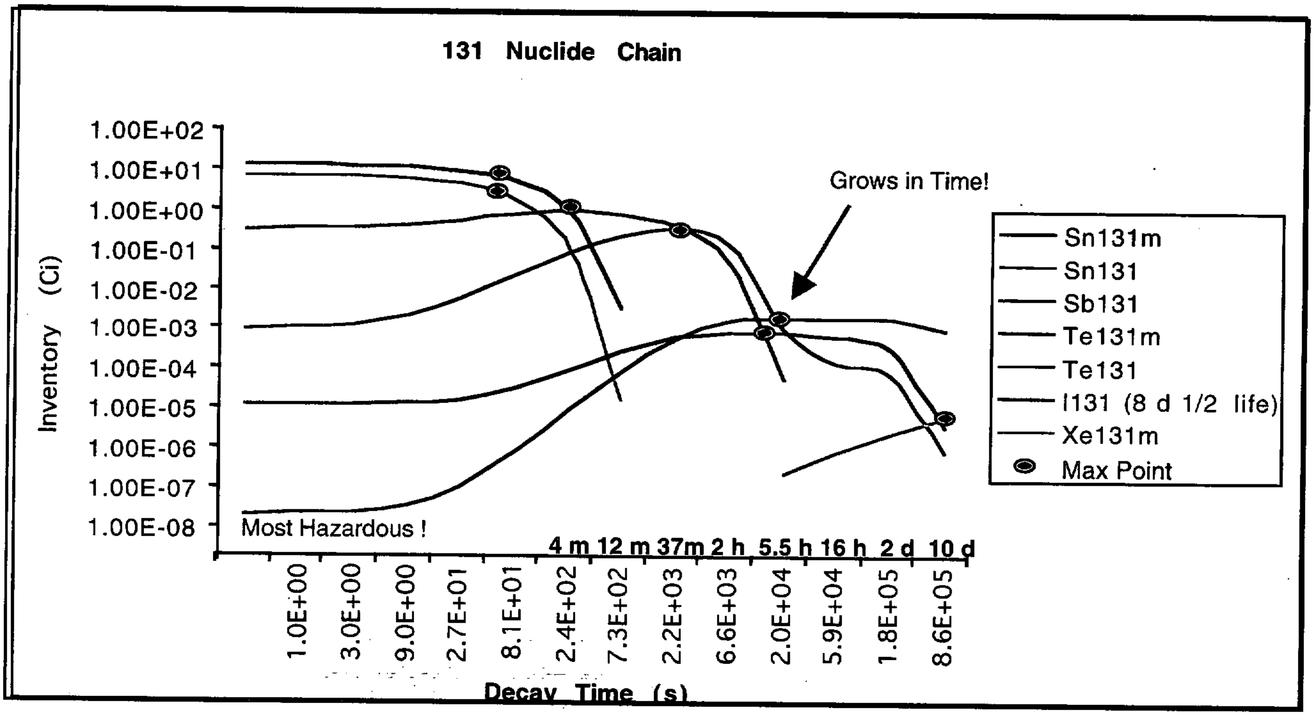


Figure 5 Example - Growth and Decay of the 131 Nuclide Chain

The maximum release amounts were set using guidance from DOE-STD-1027-92.[20] Table 9 presents the release fraction values applied during this analysis. The selected key isotopes and associated maximum release values are shown in Appendix F.

Form	Materials	Release Fraction
Gases	H^3, Kr, Xe, Ar, Rn, Cl	0.1
Highly volatile/combustible	P, S, K, I, Na, Br	0.5
Semi-volatile	Se, Hg, Cs, Po, Te, Ru, C	0.01
Solid/powder/liquid	All materials not listed above	0.001

Table 9 Release Fractions [21]

B Routine Dose

The same routine release scenario that was used to determine the current EIS values for the Maximum Exposure to an Individual (MEI) dose and the population dose was also used to determine the impact of cocktail hohlraum utilization. The scenario incorporates a 30 Ci tritium release with all activated air and 1% iodine particulate release from a 1200 MJ annual yield year released uniformly over one year. The release point is the stack with a 35 m height, 1.1 m diameter, and a 7.3 m/s exit velocity. The MEI was calculated at the veterinarian facility located 400 m from the NIF stack. Year 2010 population and meteorological data was used in the analysis. The current EIS reflects a MEI of 0.1 mrem per year and a population dose of 0.2 person-rem per year. This MEI value is 100 times less than the EPA limit for airborne release of 10 mrem per year.

The anticipated routine dose due to cocktail hohlraum use was calculated by Mike Singh using CAP-88[22]. As stated, the same scenario outlined above was used in this analysis adding the release of appropriate levels of gaseous and particulate fission products from the worst-case year. The worst-case year is 2010 in which the first, second and third ignition campaigns are projected to be completed resulting in 8.3×10^{15} fissions. Singh calculated a MEI dose increase of 0.002 mrem per year and the population dose increases by 0.0024 person-rem per year. Both of these values are insignificant compared to the current EIS numbers previously stated.

C Beyond Design Accident Dose

The same beyond design basis accident scenario that was used to determine the current EIS values for the MEI dose and the population dose was also used to determine the impact of cocktail hohlraum utilization. The scenario entails a severe earthquake occurrence at the instant a 45 MJ yield shot is fired. The resulting release to the environment is all the activated air, appropriate percentages of particulate (from Table 9), and the maximum inventory of tritium: 500 Ci. The release point is the worst-case ground level with moderately stable meteorological conditions and a 1 m/s wind velocity. This scenario is unrealistic because a ground level release is not possible however, it does provide an upper bound for release conditions.

The current EIS reflects a MEI dose of 0.2 rem and a population dose of 440 person-rem. This MEI value is 125 times less than the design basis for reactor siting requirements of 25 rem. In determining these two doses, another impossibility is incorporated into the calculation to provide an upper bound. The MEI is calculated at the veterinarian facility but the population dose is calculated in the opposite direction for the sector which includes the population of San Francisco and Oakland. This means that the wind would have to be blowing in two different directions simultaneously for both doses to be valid.

Gretchen Gallegos computed the anticipated accident doses due to the use of cocktail hohlraums using GENII[23]. The same conditions were assumed with the inclusion of fission products from a 45 MJ yield shot. The calculated doses are a MEI dose of 0.037 rem and a population dose of 7 person-rem. The MEI value is within the rounding margin for the current EIS value of 0.2 rem. The population dose would increase to 447 person-rem which is a 0.2 percent increase from previous calculations.

The safety consequences were also calculated to incorporate cocktail hohlraum use. Table 10 provides the radiological consequences resulting from a 45 MJ shot at three locations from target bay center. The beyond design basis accident and safety dose calculations from GENII are given in Appendix G.

Location/ Meteorology	30 m, Class D stability, 4.5 m/s wind speed	100 m, Class F stability, 1 m/s wind speed	350 m, Class F stability, 1 m/s wind speed
Dose (rem)	0.17	0.52	0.047

Table 10 Beyond Design Basis Event Consequences

D Facility Hazard Classification

NIF has a facility hazard classification of Radiological Facility. To meet the conditions for this category, two requirements must be met. The first requisite entails taking the ratio of each inventory of activation products over the threshold value from DOE 1027-92. The requirement is that the sum of these ratios must be less than one. The other requirement is a dose calculation at 30 m from the release, ground level, a 4.5 m/s wind and neutral meteorological stability. This dose must be less than 10 rem.

The current safety estimates for these two requirements are 0.3 for the sum of the ratios and a 3.6 rem dose calculation. After taking the sum of the ratios for all of the isotopes with threshold values (over 300 activation products), the new value for the sum of the ratios is 0.303. The dose calculation is presented in Table 10 above (rounded to 0.2 rem) to result in a total dose of 3.8 rem. Both of the requirements for a Radiological Facility are therefore met. Consequently, cocktail hohlraum use will not change the facility hazard classification of NIF.

V Conclusions

Based on a the analysis presented, the introduction of cocktail hohlraums as target types in high yield experiments does not significantly change previous safety and environmental analysis conclusion. It may be necessary to establish new thresholds for uranium and beryllium that will bound the projected amounts presented here while allowing for greater flexibility for future target development. The recommended values for these thresholds are 100 g for uranium and 10g for beryllium per year. The use of uranium in high yield experiments and subsequent production of fission products is also an issue to be addressed. A recommended maximum number of 1 x 10^{17} fissions per year provides an adequate upper bound for future experimentation.

To check the validity of the analysis presented here a number of comparisons with other methods and previous work were conducted. A discussion of these comparisons is in part A below. Finally, a number of issues which should be addressed are in part B.

A Confidence in Analysis

The output from ACAB was compared to two independent analyses. The maximum inventories for the key isotopes were in agreement with Mike Singh's 1977 calculations.[24] Singh's 77' calculations were subsequently verified by another independent calculation. Nuclide chain graphs generated from the ACAB output were also in agreement with Singh's previous calculations. Based on these comparisons, it was concluded that the maximum key isotope inventories are valid.

The GENII dose calculations were compared to three independent analyses. The inhalation doses from were verified by HOTSPOT calculations.[25] The dose rates were also compared with COMPLY: V1.6 and found to be in agreement.[26] Finally, the dose rates were compared with previous calculations by Chin Ma.[27] Based on these comparisons, it was concluded that the dose calculations from Genie are valid.

B Issues

While comparing the ACAB output to other calculations of isotope inventories for t = 0 (i.e. the instant after the shot), some discrepancies were present. Even though the maximum inventories to the key isotopes were in agreement, there may be an issue with how ACAB calculated the t=0 inventories and with how these inventories grow to maximum values. Further analysis is required to determine the differences in the physics model for the different methods of calculations.

The waste and decontamination plans should also be analyzed to determine additional requirements due to the production of fission products. The Waste/Decon Category does not likely change but this should be verified. A plan to ensure fission products are kept out of the Optics Assembly Building (OAB) also needs future analysis.

Finally, the build up of fission products in the target bay for a 6-month period prior to an accidental release also needs further analysis. ACAB can best provide the decay and growth inventories of the key isotopes over a 6-month period. Initial estimates indicate that residual fission products in the target bay will result in an insignificant increase in dose.

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Appendix A Number of Shots per Year

This Appendix contains the projected number of NIF shots per year from 2003 to 2011 by requested class of experiment.

Year	2003

Sum of Shots	
Experiment	Total
Early EOS exps	5
Early Planar Hydro Experiment (Vert Hohlraum)	10
Laser Timing Verification	5
NWET - Radiation Source Experiment	5
Rad T Halfraum Experiment	5
Test Drive Diagnostics	20
Verify Backscatter Diagnostics/NWET	15
Low Yield Diagnostic Use	
Grand Total	65

Year	2004

Sum of Shots	
Experiment	Total
Early EOS exps	16
Early Planar Hydro Experiment (Vert Hohlraum	5
Early planar hydro exps	5
ignition campaign single bundle exps	7
Laser Timing Verification	5
Melt/refreeze diagnostic dev.	2
NWET - Radiation Source Experiment	4
Rad T Halfraum Experiment	7
Single Cluster Shock Tube Experiment	15
Test Drive Diagnostics	15
Verify Backscatter Diagnostics/NWET	19
Grand Total	100

Year	2005

Sum of Shots	
Experiment	Total
Early EOS exps	10
Early Planar Hydro Experiment (Vert Hohlraum)	5
Early planar hydro exps	15
ignition campaign single bundle exps	28
Laser Timing Verification	5
Melt/refreeze diagnostic dev.	8
NWET - Radiation Source Experiment	7
Undefined Shots	70
Single Cluster Shock Tube Experiment	10
Test Drive Diagnostics	5
Verify Backscatter Diagnostics/NWET	27
Grand Total	190

Appendix A Number of Shots per Year

Year	2006

Sum of Shots	
Experiment	Total
continuing opacity exps (vert hohlraum)	10
continuing strength exps (vert hohlraum)	10
First cluster EOS exps	15
First cluster integrated exps (horiz halfraum)	30
First cluster opacity exps (vert hohlraum)	20
First cluster planar hydro exps	15
First cluster rad-hydro exps (horiz halfraum)	30
First cluster strength exps (vert hohlraum)	20
ignition campaign halfraum exps	76
ignition campaign single bundle exps	6
Low Yield Diagnostic Development	15
Melt/refreeze diagnostic dev.	2
NWET - Radiation Source Experiment	3
Grand Total	252

Year	2007

Sum of Shots	
Experiment	Total
Beginning horizontal foil EOS exps	20
Beginning horizontal foil planar hydro exps	15
beginning melt/refreeze exps (32 beams)	14
beginning non-ideal implosions exps (64 beams)	14
continuing integrated exps (vert halfraum)	20
continuing opacity exps (vert hohlraum)	10
continuing rad-hydro exps (vert halfraum)	20
continuing strength exps (vert hohlraum)	30
Convergent hydro (vert hohlraum)	20
Cylindrical implosions (vert hohlraum)	20
Exps preliminary to opacity (48 beams)	20
First cluster EOS exps	5
First cluster planar hydro exps	5
ignition campaign halfraum exps	4
symmetry and capsule physics	35
Grand Total	252

Appendix A Number of Shots per Year

Year	2008

Sum of Shots	
Experiment	Total
128-beam convergent hydro	20
128-beam cylindrical implosions	20
64-beam integrated exps	20
64-beam rad-hydro exps	20
96-beam convergent hydro	20
96-beam cylindrical implosions	20
Beginning horizontal foil planar hydro exps	5
Continuing melt/refreeze exps (64 beams)	30
Continuing horizontal foil EOS exps	20
Continuing non-ideal implosions (128 beams)	24
Continuing non-ideal implosions (96 beams)	14
convergent hydrodynamics	7
cylindrical implosions	7
Exps preliminary to opacity (80 beams)	21
Exps preliminary to strength (80 beams)	21
Exps preliminary to strength w/surrogates	14
integrated exps	14
laser mix	21
Low Yield Diagnostic Development	25
NWET - Radiation Source Experiment	20
opacity 1	15
Undefined Shots	10
pre-ignition 96 beams	101
pre-ignition campaign (mid fluence)	1
rad-hydro	14
symmetry and capsule physics	12
U EOS (low fluence)	15
Verify Backscatter Diagnostics/NWET	19
Grand Total	550

Appendix A Number of Shots per Year

Year	2009

Sum of Shots	
Experiment	Total
Continuing melt/refreeze exps (64 beams)	6
convergent hydrodynamics	28
cylindrical implosions	28
Exps preliminary to strength w/surrogates	28
first ignition campaign (high fluence)	3
Ignition diag development - yield	20
integrated exps	27
laser mix	28
Low Yield Diagnostic Development	40
melt/refreeze (low fluence)	20
melt/refreeze (mid fluence)	2
non-ideal implosions	28
NWET - Radiation Source Experiment	23
opacity 1	31
Undefined Shots	119
pre-ignition campaign (high fluence)	65
pre-ignition campaign (mid fluence)	79
rad-hydro	27
U EOS (high fluence)	5
U EOS (low fluence)	5
U EOS (mid fluence)	21
Verify Backscatter Diagnostics/NWET	23
Grand Total	656

Appendix A

Number of Shots per Year

Year	2010

Sum of Shots	
Experiment	Total
convergent hydrodynamics	7
cylindrical implosions	7
Exps preliminary to strength w/surrogates	7
first ignition campaign (high fluence)	67
first ignition campaign (high fluence) yield	10
laser mix	14
melt/refreeze (high fluence)	12
melt/refreeze (mid fluence)	19
non-ideal implosions	21
NWET - Radiation Source Experiment	25
opacity 1	15
opacity 2	15
Undefined Shots	187
second ignition campaign (high fluence)	70
second ignition campaign (high fluence) yield	10
strength w/surrogates (low fluence)	20
strength w/surrogates (mid fluence)	2
third ignition campaign (high fluence)	70
third ignition campaign (high fluence) yield	10
U EOS (high fluence)	17
uses of ignition 1 yield	1
uses of ignition 2 yield	1
Verify Backscatter Diagnostics/NWET	26
Grand Total	633
Equivalent Shots	727

Year	2011

Sum of Shots	
Experiment	Total
melt/refreeze (high fluence)	8
NWET - Radiation Source Experiment	26
opacity 2	15
opacity 3	16
Undefined Shots	273
strength w/surrogates (High fluence)	13
strength w/surrogates (mid fluence)	19
U EOS (high fluence)	44
U EOS (high fluence) yield	4
uses of ignition 1 (256 equiv)	21
uses of ignition 1 yield	9
uses of ignition 2 (130 equiv)	21
uses of ignition 2 yield	9
Verify Backscatter Diagnostics/NWET	27
Grand Total	505
Equivalent Shots	746

Appendix B Classes of Experiments by Target Type

This page of Appendix B provides a complete list of the base shapes, appendages, and associated abbreviations used in the model for brevity. The following pages provide the assumed target types for each class of experiment.

Abbreviations

Type	Description	Abbreviation
Base	Direct Drive Planar Disk	PD
	Direct Drive Planar Wedge	PW
	Direct Drive Planar Square	PS
	Direct Drive Cylinder	DDC
	Spherical Gas Bag	SGB
	Radiation Source	RS
	Spherical Capsule	SC
	Halfraum	Half
	Hohlraum	Hohl
	Direct Drive Cryo Planar	CP
	Cryo Halfraum	CHalf
	Cryo Hohlraum	CHohl
Appendages	Back Lighter	a
	Rectangular Shield	b1
	Circular Shield	b2
	Conical Shield	b3
	Diagnostic - Camera Shield (x2)	c
	Capsule	d1
	Capsule w/DT	d1Y
	Shock Tube	d2
	Witness Plate	d3
	Foam Filler	d4
	Planar Package	d5
	Cylindrical Package	d6
	Filler Tube	e1
	Stalk	e2

Appendix B Classes of Experiments by Target Type

Experiment	Base	Scale	Target Type
Ignition campaign single bundle exps	PD	1	b1, c, d4, e2
Ignition campaign single bundle exps	SGB	1	b1, c, e1, e2
Ignition campaign halfraum exps	CHalf	1	a,b2,c,d1,d5
Symmetry and capsule physics	CHohl	1	a,b2,c,d1Y, d3, d5
Pre-ignition 96 beams	CHohl	1	a,b1,c,d1, d3, d5
Pre-ignition campaign (high fluence)	CHohl	1	a, b1, c, d1
Pre-ignition campaign (mid fluence)	CHohl	1	a,b1, c, d1
First ignition campaign (high fluence)	CHohl	1	a, b1, c, d1
First ignition campaign (high fluence) yield	CHohl	1	a, b1, c, d1Y
Second ignition campaign (high fluence)	CHohl	1	a, b1, c, d1
Second ignition campaign (high fluence) yield	CHohl	1	a, b1, c, d1Y
Third ignition campaign (high fluence)	CHohl	1	a, b1, c, d1
Third ignition campaign (high fluence) yield	CHohl	1	a, b1, c, d1Y
Uses of ignition 1 (256 equiv)	CHohl	1	a, b1, c, d1, d5
Uses of ignition 1 yield	CHohl	1	a, b1, c, d1Y, d5
Uses of ignition 2 (130 equiv)	CHohl	1	a, b1, c, d1, d5
Uses of ignition 2 yield	CHohl	1	a, b1,d1Y,d5
Early EOS exps	PD	1	a, b2, c, d3, e2
Early EOS exps	PD	1	a, b2, c,d3, e2
First cluster EOS exps	PD	1	a, b2, c, d3, e2
First cluster EOS exps	CP	1	a, b2, c,d3, e2
Beginning horizontal foil EOS exps	PD	1	a, b2, c, d3, e2
Beginning horizontal foil EOS exps	CP	1	a, b2, c,d3, e2
Continuing horizontal foil EOS exps	PD	1	a, b2, c, d3, e2
Continuing horizontal foil EOS exps	CP	1	a, b2, c,d3, e2
U EOS (low fluence)	PD	1	a, b2, c,d3, e2
U EOS (mid fluence)	PD	1	a, b2, c,d3, e2
U EOS (high fluence)	PD	1	a, b2, c,d3, e2
U EOS (high fluence)	PD	1	a, b2, c, d1, d3, e1, e2
U EOS (high fluence) yield	CP	1	a, b2, c, d1Y, d3, e1, e2
First cluster opacity exps (vert hohlraum)	Hohl	0.25	c, d3, d4, e2
Continuing opacity exps (vert hohlraum)	Hohl	0.25	c, d3, d4, e2
Exps preliminary to opacity (48 beams)	Hohl	0.25	c, d3, d4, e2
Exps preliminary to opacity (80 beams)	Hohl	0.5	c, d3, d4, e2
Opacity 1	Hohl	0.75	c, d3, d4, e2
Opacity 2	Hohl	0.75	c, d3, d4, e2
Opacity 3	Hohl	0.75	c, d3, d4, e2
Early Planar Hydro Experiment (Vert Hohlraum)	Half	1	a, b1, b2, c, d5, e2
Early planar hydro exps	PD	1	a, b2, c, d2, d4, d5, e2
First cluster planar hydro exps	PD	1	a, b2, c, d2, d4, d5, e2
Beginning horizontal foil planar hydro exps	PD	1	a, b2, c, d2, d4, d5, e2
Laser mix	PD	1	a, b2, c, d4, d5, e2
Beginning non-ideal implosions exps (64 beams)	SC	1	a, c, e1, e2
Continuing non-ideal implosions (96 beams)	SC	1	a, c, e1, e2
Continuing non-ideal implosions (128 beams)	SC	1	a, c, e1, e2
Non-ideal implosions	SC	1	a, c, e1, e2

Appendix B Classes of Experiments by Target Type

Experiment	Base	Scale	Target Type
First cluster rad-hydro exps (horiz halfraum)	Half	1	a, b2, c, d2, d4, e2
Continuing rad-hydro exps (vert halfraum)	Half	1	a, b2, c, d2, d4, e2
64-beam rad-hydro exps	Half	1	a, b2, c, d2, d4, e2
Rad-hydro	Half	1	a, b2, c, d2, d4, e2
First cluster strength exps (vert hohlraum)	Hohl	2	a, b1, c, d5, e2
First cluster strength exps (vert hohlraum)	PD	1	a, b2, c, d5, e2
Continuing strength exps (vert hohlraum)	Hohl	2	a, b1, c, d5, e2
Continuing strength exps (vert hohlraum)	PD	1	a, b2, c, d5, e2
Exp preliminary to Strength (48 Beams)	PD	1	a, b2, c, d5, e2
Exp preliminary to Strength (48 Beams)	Hohl	2	a, b1, c, d5, e2
Exps preliminary to strength (80 beams)	Hohl	2	a, b1, c, d5, e2
Exps preliminary to strength (80 beams)	PD	1	a, b2, c, d5, e2
Exps preliminary to strength w/surrogates	Hohl	2	a, b1, c, d5, e2
Exps preliminary to strength w/surrogates	PD	1	a, b2, c, d5, e2
Strength w/surrogates (low fluence)	Hohl	2	a, b1, c, d5, e2
Strength w/surrogates (low fluence)	PD	1	a, b2, c, d5, e2
Strength w/surrogates (mid fluence)	Hohl	2	a, b1, c, d5, e2
Strength w/surrogates (mid fluence)	PD	1	a, b2, c, d5, e2
Strength w/surrogates (High fluence)	Hohl	2	a, b1, c, d5, e2
Strength w/surrogates (High fluence)	PD	1	a, b2, c, d5, e2
Melt/refreeze diagnostic dev.	DDC	1	a, b2, c, d4, e2
Melt/refreeze diagnostic dev.	Hohl	2	a, b2, c, d5, e2
Beginning melt/refreeze exps (32 beams)	DDC	1	a, b2, c, d4, e2
Beginning melt/refreeze exps (32 beams)	Hohl	2	a, b2, c, d5, e2
Continuing melt/refreeze exps (64 beams)	DDC	1	a, b2, c, d4, e2
Continuing melt/refreeze exps (64 beams)	Hohl	2	a, b2, c, d5, e2
Melt/refreeze (low fluence)	DDC	1	a, b2, c, d4, e2
Melt/refreeze (low fluence)	Hohl	2	a, b2, c, d5, e2
Melt/refreeze (mid fluence)	DDC	1	a, b2, c, d4, e2
Melt/refreeze (mid fluence)	Hohl	2	a, b2, c, d5, e2
Melt/refreeze (high fluence)	DDC	1	a, b2, c, d4, e2
Melt/refreeze (high fluence)	Hohl	2	a, b2, c, d5, e2
First cluster integrated exps (horiz halfraum)	Half	1	a, b1, b2, c, d1, d2, d3, e1, e2
Continuing integrated exps (vert halfraum)	Half	1	a, b1, b2, c, d1, d2, d3, e1, e2
64-beam integrated exps	Half	1	a, b1, b2, c, d1, d2, d3, e1, e2
Integrated exps	Half	1	a, b1, b2, c, d1, d2, d3, e1, e2
Cylindrical implosions (vert hohlraum)	Hohl	2	a, b1, b2, c, d6, e2
96-beam cylindrical implosions	Hohl	2	a, b1, b2, c, d6, e2
128-beam cylindrical implosions	Hohl	2	a, b1, b2, c, d6, e2
Cylindrical implosions	Hohl	2	a, b1, b2, c, d6, e2

Appendix B Classes of Experiments by Target Type

Experiment	Base	Scale	Target Type
96-beam convergent hydro	Hohl	1	a, b1, c, d1, e1, e2
96-beam convergent hydro	SC	1	a, c, d1, e1, e2
128-beam convergent hydro	Hohl	1	a, b1, c, d1, e1, e2
128-beam convergent hydro	SC	1	a, c, d1, e1, e2
Convergent hydro (vert hohlraum)	Hohl	1	a, b1, c, d1, e1, e2
Convergent hydrodynamics	SC	1	a, c, d1, e1, e2
Laser Timing Verification	PS	1	c, e2
Laser Timing Verification	PW	1	c, e2
Low Yield Diagnostic Use	SC	0	a, c, d1Y, e1, e2
Rad T Halfraum Experiment	Half	1	b1, b3, c, d4, e2
Single Cluster Shock Tube Experiment	Half	1	b1, b2, c, d2, d4, e2
Test Drive Diagnostics	Hohl	0.6	b1, c, d3, e2
Test Drive Diagnostics	PD	1	c, e2
NWET - Radiation Source Experiment	RS	4	c, d4, e1, e2
Verify Backscatter Diagnostics/NWET	PD	4	c, e1, e2
Verify Backscatter Diagnostics/NWET	SGB	1	c, e1, e2

Notes: Dan Kalantar and Nino Landen provided the typical target for each experiment.
Gail Glendinning verified convergent hydro/non-ideal target types.
Tina Back verified the target type for Rad/Hydro Experiments.
Mike Miller verified target type and materials for NWET targets. He also said that an experiment could have up to 4 radiation sources as one target (Hence, scale 4).

Appendix C Target Bases and Appendages Geometry

This appendix provides the assumed dimensions and volumes of material for each target component.

	Direct Drive Planar
Description	DD Planar - Disk (PD)
Thickness (cm)	2.500E-03
Diameter (cm)	5.000E-01
Volume (cc)	4.909E-04
Coating	
Thickness	5.000E-04
Volume (cc)	9.842E-07

	Direct Drive Planar
Description	DD Planar - Wedge (PW)
Thickness (cm)	5.000E-02
Width (cm)	6.000E-01
Length (cm)	2.000E+00
Volume (cc)	3.000E-02
Coating	
Thickness	5.000E-04
Volume (cc)	3.328E-04

	Direct Drive Planar
Description	DD Planar - Square (PS)
Thickness (cm)	2.000E-02
Width (cm)	2.000E+00
length (cm)	2.000E+00
Volume (cc)	8.000E-02
Coating	
Thickness	5.000E-04
Volume (cc)	2.041E-03

	Direct Drive Cylindrical
Description	DD Cylind - (DDC)
Inner Diam (cm)	2.400E-01
Outer Diam (cm)	2.500E-01
Height (cm)	1.000E+00
Volume (cc)	3.848E-03
Coating	
Inner Diam (cm)	2.500E-01
Outer Diam (cm)	2.505E-01
Height (cm)	1.000E+00
Volume (cc)	1.965E-04

	Direct Drive Spherical
Description	Spherical Gas Bag - (SGB)
Base - assumed insignificant mass	
Washer	
Inner Diam (cm)	3.000E-01
Outer Diam (cm)	4.000E-01
Thickness (cm)	4.000E-02
Volume (cc)	2.199E-03
Fill	
Outer Diameter	2.990E-01
Volume (cc)	1.400E-02

	Direct Drive Spherical
Description	Radiation Source - (RS)
Inner Diam (cm)	6.990E-01
Outer Diam (cm)	7.000E-01
Volume (cc)	7.686E-04
Filler	
Outer Diam (cm)	6.990E-01
Volume (cc)	1.788E-01

Appendix C Target Bases and Appendages Geometry

	Direct Drive Spherical
Description	Spherical Capsule - (SC)
Inner Diam (cm)	2.000E-01
Outer Diam (cm)	2.001E-01
Volume (cc)	3.142E-06
Fill	
Outer Diam (cm)	2.000E-01
Volume (cc)	4.189E-03

	Halfraum
Description	Halfraum - (Half)
Thickness (cm)	2.500E-03
Length (cm)	5.000E-01
Outer diam(cm)	6.000E-01
Inner diam (cm)	3.000E-01
Volume (cc)	3.416E-03
Coating	
Thickness	1.000E-03
Length (cm)	5.000E-01
Diameter (cm)	6.005E-01
Inner diam (cm)	6.000E-01
Volume (cc)	9.442E-04

	Hohlraum
Description	Hohlraum - (Hohl)
Thickness (cm)	2.500E-03
Length (cm)	1.000E+00
Outer diam (cm)	6.000E-01
Inner diam (cm)	3.000E-01
Volume (cc)	5.773E-03
Coating	
Thickness	1.000E-03
Length (cm)	1.000E+00
Outer diam (cm)	6.005E-01
Inner diam (cm)	6.000E-01
Volume (cc)	1.887E-03

	Cryo
Description	DD Cryo-Planar - (CP)
Inner Diam (cm)	5.000E-01
Outer Diam (cm)	5.400E-01
Length (cm)	5.000E-02
Volume (cc)	1.634E-03
Coating	
Inner Diam (cm)	5.400E-01
Outer Diam (cm)	5.900E-01
Length (cm)	5.000E-02
Volume (cc)	2.219E-03
Fill	
Outer Diam (cm)	5.400E-01
Length (cm)	5.000E-02
Volume (cc)	1.145E-02
Window	
Thickness (cm)	5.000E-03
Outer Diam (cm)	2.000E-01
Volume (cc)	1.571E-04

	Cryo
Description	Cryo-Halfraum - (CHalf)
Halfraum	
Thickness (cm)	3.500E-03
Length (cm)	5.000E-01
Outer diam (cm)	6.000E-01
Inner diam (cm)	3.000E-01
Volume (cc)	4.783E-03
Cooling rings	
Inside diam (cm)	7.000E-01
Outside diam (cm)	9.000E-01
Thickness (cm)	1.500E-01
Volume (cc)	7.540E-02
Sapphire rods	
Diameter (cm)	5.000E-02
Length (cm)	5.000E+00
Volume (cc)	1.963E-02

	Cryo
Description	Cryo-Hohlraum - (CHohl)
Hohlraum	
thickness (cm)	3.500E-03
length (cm)	1.000E+00
Outer diam (cm)	6.000E-01
Inner diam (cm)	3.000E-01
volume (cc)	8.082E-03
Cooling rings	
inside diam (cm)	7.000E-01
outside diam (cm)	9.000E-01
thickness (cm)	1.500E-01
volume (cc)	7.540E-02
Sapphire rods	
diameter (cm)	5.000E-02
length (cm)	1.000E+01
volume (cc)	3.927E-02

Appendix C Target Bases and Appendages Geometry

	Appendage a
Description	Back lighter - (a)
Diameter (cm)	5.000E-01
Thickness (cm)	2.500E-03
Volume (cc)	4.909E-04
Cu Rod	
Diameter (cm)	5.000E-02
Length (cm)	1.000E+00
Volume (cc)	1.963E-03
Metal Foil	
Diameter (cm)	5.000E-01
Thickness (cm)	5.000E-04
Volume (cc)	9.817E-05

	Appendage b1
Description	Shield - rectangular (b1)
thickness (cm)	1.000E-03
Width (cm)	5.000E-01
Length (cm)	5.000E-01
Volume (cc)	2.500E-04
Coating	
thickness (cm)	5.000E-04
Width (cm)	5.000E-01
Length (cm)	5.000E-01
Volume (cc)	1.258E-04

	Appendage b2
Description	Shield - circular (b2)
Diameter (cm)	2.000E+00
Thickness (cm)	2.500E-03
Volume (cc)	7.854E-03

	Appendage b3
Description	Shield - conical (b3)
Thickness (cm)	2.500E-03
Inner Diam (cm)	1.000E-01
Outer Diam (cm)	1.000E+00
Length (cm)	1.000E+00
Volume (cc)	2.893E-03
Coating	
Thickness (cm)	1.000E-03
Inner Diam (cm)	1.025E-01
Outer Diam (cm)	1.003E+00
Length (cm)	1.000E+00
Volume (cc)	1.159E-03

	Appendage c
Description	Diagnostics camera x2 - (c)
Thickness (cm)	1.000E-03
Inner Diam (cm)	5.000E-01
Outer Diam (cm)	1.000E+00
Volume (cc)	5.890E-04
Fill	
Outer Diam (cm)	5.000E-01
Thickness (cm)	5.000E-03
Volume (cc)	9.817E-04

	Appendage d1
Description	Capsule - No Yield
inner Diam (cm)	2.000E-01
Outer Diam (cm)	2.160E-01
Volume (cc)	1.088E-03
Fill	
Diameter (cm)	2.000E-01
Volume (cc)	4.189E-03

	Appendage d1Y
Description	Capsule - Yield
inner Diam (cm)	2.000E-01
Outer Diam (cm)	2.160E-01
Volume (cc)	1.088E-03
Fill	
Diameter (cm)	2.000E-01
Volume (cc)	4.189E-03

	Appendage d2
Description	Shock Tube
inner Diam (cm)	2.500E-01
Outer Diam (cm)	3.000E-01
Length (cm)	1.000E+00
Volume (cc)	2.160E-02
Fill	
Diameter (cm)	2.500E-01
Volume (cc)	8.181E-03

Appendix C Target Bases and Appendages Geometry

	Appendage d3
Description	Witness Plate
Length (cm)	3.000E-01
Width (cm)	5.000E-02
Thickness (cm)	1.500E-02
Volume (cc)	2.250E-04

	Appendage d4
Description	Foam Filler
Length (cm)	1.000E+00
Diameter (cm)	5.000E-01
Volume (cc)	1.963E-01

	Appendage d5
Description	Planar Package
Diameter(cm)	3.000E-01
Thickness (cm)	1.000E-02
Volume (cc)	7.069E-04
Coating (cm)	
Thickness	5.000E-04
Diameter(cm)	3.100E-01
Volume (cc)	2.395E-06

	Appendage d6
Description	Cylindrical Package
Outer Diam (cm)	2.000E-01
Length (cm)	6.000E-01
Volume (cc)	1.885E-02
Coating (cm)	
Thickness	5.000E-04
Inner Diam (cm)	2.000E-01
Outer Diam (cm)	2.005E-01
Length (cm)	6.000E-01
Volume (cc)	9.437E-05

	Appendage e1
Description	Filler Tube
inner Diam (cm)	3.000E-02
Outer Diam (cm)	3.500E-02
length (cm)	5.000E+00
Volume (cc)	1.276E-03

	Appendage e2
Description	Stalk
Outer Diam (cm)	1.000E-01
Length (cm)	5.000E+00
Volume (cc)	3.927E-02

Appendix D Material Assumptions

This appendix provides the material assumptions for each target component. The materials were chosen based to provide an upper bound for uranium and beryllium as well as to consider worst case environmental impacts.

Description		Assumption
Direct Drive Planar Disk	PD	Assumes CH coated w/ Au
Direct Drive Planar Wedge	PW	Assumes Al coated w/Au
Direct Drive Planar Sphere	PS	Assumes Al coated w/Au
Direct Drive Cylinder	DDC	Assumes Ta coated w/CH
Spherical Gas Bag	SGB	Assumes insignificant Polyimid bag mass, Al washer, Xe, 1 atm, 293K
Radiation Source	RS	Assumes Be filled w/Kr, 1 atm, 293K
Spherical Capsule	SC	Assumes CH filled w/D2, 100 atm, 293 K
Halfraum	Half	Assumes Au coated w/CH
Hohlraum	Hohl	Assumes Au coated w/CH
Direct Drive Cryo Planar	CP	Assumes Al coated w/ LiF, filled w/D, 100 atm, 2 Be windows
Cryo Halfraum	CHalf	Assumes Cocktail* w/Cu rings, Sapphire rods
Cryo Hohlraum	CHohl	Assumes Cocktail* w/Cu rings, Sapphire rods
Backlighter	a	Assumes Ta substrate, Iron foil, Cu pole
Rectangular Shield	b1	Assumes Ta Shield coated w/CH
Circular Shield	b2	Assumes Cu Shield
Conical Shield	b3	Assumes Au Shield coated w/CH
Diagnostic - Camera Shield	c	Assumes Fe base with Be
Capsule	d1	Assumes Be w/D 400 atm, 293K
Capsule	d1Y	Assumes Be w/DT 400 atm, 293K
Shock Tube	d2	Assumes Be filled w /Ta(2)O(5)foam (81.9%Ta)
Witness Plate	d3	Assumes Al plate
Foam Filler	d4	Assumes Ta(2)O(5) Foam (81.9% Ta)
Planar Package	d5	Assumes Be coated w/Au
Cylindrical Package	d6	Assumes C (TPX) Foam filling w/ Au coating
Filler Tube	e1	Assumes Fe
Stalk	e2	Assumes SiO(2) (53.3% O)

* Cocktail = 60% U, 20% Dy, 20% Au (atomic mass)

Notes: Dan Kalantar matched most of the materials with the target bases/appendages.
Gail Glendinning provided the composition of foam filler (d4).
Larry Suter provided the worst case cocktail material for use in ignition.

Appendix E Amount of Material by Year

This appendix provides the total sum of materials by year from 2003 to 2011.

Experiments	All	Year			
Material (mg)	2003	2004	2005	2006	2007
Al	1.45E+03	1.53E+03	2.78E+03	2.49E+03	2.44E+03
Au	4.07E+03	5.92E+03	6.91E+03	9.43E+03	1.62E+04
Be	5.55E+02	2.40E+03	4.77E+03	4.30E+03	3.54E+03
C	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.54E+01
CH	1.10E+02	1.65E+02	2.55E+02	1.47E+02	2.79E+02
Cu	2.64E+03	7.04E+03	1.28E+04	6.80E+04	4.00E+04
Dy	0.00E+00	0.00E+00	0.00E+00	4.70E+02	3.90E+02
Fe	1.63E+03	2.43E+03	5.32E+03	3.04E+03	3.04E+03
Kr	2.49E+01	1.99E+01	5.53E+01	7.48E+00	0.00E+00
Li	0.00E+00	0.00E+00	0.00E+00	2.22E+00	4.13E+00
F	0.00E+00	0.00E+00	0.00E+00	1.93E+01	3.58E+01
O	3.08E+03	4.88E+03	9.30E+03	7.93E+03	8.68E+03
Si	5.55E+03	8.54E+03	1.62E+04	7.52E+03	9.10E+03
Ta	7.75E+02	2.08E+03	4.70E+03	3.42E+03	4.14E+03
U	0.00E+00	0.00E+00	0.00E+00	4.52E+03	3.75E+03
Xe	1.07E+00	1.99E+00	7.99E+00	4.59E-01	0.00E+00
Deuterium	0.00E+00	0.00E+00	0.00E+00	3.09E+01	1.69E+01
Tritium	0.00E+00	0.00E+00	0.00E+00	7.84E-02	1.83E+00
Tritium (Ci)	0.00E+00	0.00E+00	0.00E+00	7.53E-01	1.76E+01
Number of Neutrons	0.00E+00	0.00E+00	0.00E+00	1.07E+16	2.49E+16

Experiments	All	Year		
Material (mg)	2008	2009	2010	2011
Al	9.06E+03	1.29E+04	2.14E+04	8.52E+03
Au	3.16E+04	2.87E+04	2.50E+04	1.96E+04
Be	5.65E+03	5.82E+03	4.51E+03	3.38E+03
C	1.80E+02	1.29E+02	3.75E+01	0.00E+00
CH	5.44E+02	4.92E+02	4.03E+02	4.13E+02
Cu	1.20E+05	1.63E+05	2.47E+05	1.05E+05
Dy	1.48E+03	2.13E+03	3.54E+03	1.36E+03
Fe	6.81E+03	8.51E+03	1.04E+04	8.33E+03
Kr	5.08E+01	7.00E+01	8.85E+01	1.41E+02
Li	0.00E+00	0.00E+00	0.00E+00	2.76E+00
F	0.00E+00	0.00E+00	0.00E+00	2.40E+01
O	2.32E+04	3.01E+04	3.90E+04	2.14E+04
Si	1.74E+04	1.93E+04	1.25E+04	1.60E+04
Ta	8.73E+03	1.02E+04	1.06E+04	6.57E+03
U	1.42E+04	2.05E+04	3.41E+04	1.31E+04
Xe	7.01E-01	1.03E+00	1.41E+00	2.16E+00
Deuterium	5.79E+01	8.05E+01	1.00E+02	6.72E+01
Tritium	1.97E+00	1.05E+01	1.90E+01	2.00E+01
Tritium (Ci)	1.89E+01	1.01E+02	1.82E+02	1.92E+02
Number of Neutrons	2.22E+17	7.46E+18	5.54E+19	6.67E+19

Appendix F Key Isotopes and Maximum Release Inventories

This appendix contains the 61 selected key isotopes that were used to assess the effects of cocktail hohlraum use on the environment.

Isotope	Max Released Ci
C14	4.30E-13
Cs134M	3.70E-11
Cs137	1.91E-08
H3	4.00E+00
I122	2.01E-07
I123	9.03E-08
I124	1.17E-08
I125	2.62E-04
I126	3.17E-09
I128	1.33E-04
I130	8.19E-07
I130M	6.10E-05
I131	9.70E-04
I132	1.92E-03
I132M	6.46E-05
I133	4.33E-03
I133M	3.16E-01
I134	1.10E-01
I134M	1.14E-01
I135	5.15E-02
I136	1.69E+00
I136M	6.55E+00
KR83M	1.42E-03
Kr85	2.15E-07
Kr85m	1.93E-02
KR87	7.12E-03
KR88	1.52E-02
KR89	2.39E+00
La140	1.99E-07
Nb95	4.75E-08
Np237	9.70E-09

Isotope	Max Released Ci
Pa233	4.16E-12
Pu239	2.17E-08
RA224	1.18E-12
RA226	4.67E-13
Rh103m	7.23E-08
Ru103	7.37E-07
Ru106	5.48E-09
Sr89	1.09E-07
Sr90	1.34E-10
Te129	6.69E-05
Te131m	3.47E-03
Th228	1.18E-12
Th230	2.16E-10
Th231	1.08E-07
Th234	2.34E-06
U232	1.72E-12
U234	3.47E-06
U235	1.08E-07
U236	3.76E-13
U238	2.34E-06
XE131M	6.45E-06
Xe133	1.12E-03
XE133M	6.32E-05
XE135	2.97E-02
XE135M	1.37E-02
XE137	1.20E+00
XE138	8.87E-01
XE139	3.46E+01
Y90	1.24E-10
Zr95	2.80E-07

Appendix G Beyond Design Accident Dose Results

This appendix has the GENII calculated output for MEI and population doses from a beyond design accident event.

Results from GENII
Maximum Individual Dose

Winter

		distance (m)	Chi/q	Total dose winter	External dose winter	Inhalation dose winter	Ingestion dose winter
				Dose in rem			
Stability class	F	100	0.051	9.30E-02	7.10E-02	2.20E-02	3.40E-05
Stability class	F	350	0.0046	8.39E-03	6.40E-03	1.98E-03	3.07E-06
Stability class	F	400	0.0036	6.56E-03	5.01E-03	1.55E-03	2.40E-06
Stability class	D	30	0.017	3.10E-02	2.37E-02	7.33E-03	1.13E-05
Controling Organ		Lung	**Pathway**	External	**Nuclide**	Kr-89	

Spring

		distance (m)	Chi/q	Total dose spring	External dose spring	Inhalation dose spring	Ingestion dose spring
				Dose in rem			
Stability class	F	100	0.051	1.00E-01	7.10E-02	2.20E-02	6.30E-03
Stability class	F	350	0.0046	9.02E-03	6.40E-03	1.98E-03	5.68E-04
Stability class	F	400	0.0036	7.06E-03	5.01E-03	1.55E-03	4.45E-04
Stability class	D	30	0.017	3.33E-02	2.37E-02	7.33E-03	2.10E-03
Controling Organ		Thyroid	**Pathway**	External	**Nuclide**	Kr-89	

Summer

		distance (m)	Chi/q	Total dose summer	External dose summer	Inhalation dose summer	Ingestion dose summer
				Dose in rem			
Stability class	F	100	0.051	1.00E-01	7.10E-02	2.20E-02	1.00E-02
Stability class	F	350	0.0046	9.02E-03	6.40E-03	1.98E-03	9.02E-04
Stability class	F	400	0.0036	7.06E-03	5.01E-03	1.55E-03	7.06E-04
Stability class	D	30	0.017	3.33E-02	2.37E-02	7.33E-03	3.33E-03
Controling Organ		Thyroid	**Pathway**	External	**Nuclide**	Kr-89	

Autumn

		distance (m)	Chi/q	Total dose autumn	External dose autumn	Inhalation dose autumn	Ingestion dose autumn
				Dose in rem			
Stability class	F	100	0.051	5.20E-01	7.10E-02	2.20E-02	4.30E-01
Stability class	F	350	0.0046	4.69E-02	6.40E-03	1.98E-03	3.88E-02
Stability class	F	400	0.0036	3.67E-02	5.01E-03	1.55E-03	3.04E-02
Stability class	D	30	0.017	1.73E-01	2.37E-02	7.33E-03	1.43E-01
Controling Organ		Thyroid	**Pathway**	Ingestion	**Nuclide**	H-3	

Results from GENII
Population Dose

Winter

		downwind distance (m)	Chi/q	Dose in person-rem: Total dose winter	External dose winter	Inhalation dose winter	Ingestion dose winter
Stability class	F	70710	6.20E-06	1.58E+00	2.14E-02	1.58E+00	3.72E-03
Controling Organ	Lung		**Pathway**	Inhalation	**Nuclide**	U-234	

Spring

		downwind distance (m)	Chi/q	Dose in rem: Total dose spring	External dose spring	Inhalation dose spring	Ingestion dose spring
Stability class	F	70710	6.20E-06	2.23E+00	2.14E-02	1.58E+00	6.70E-01
Controling Organ	Lung		**Pathway**	Inhalation	**Nuclide**	U-234	

Summer

		downwind distance (m)	Chi/q	Dose in rem: Total dose summer	External dose summer	Inhalation dose summer	Ingestion dose summer
Stability class	F	70710	6.20E-06	2.70E+00	2.14E-02	1.58E+00	1.12E+00
Controling Organ	Lung		**Pathway**	Inhalation	**Nuclide**	U-234	

Autumn

		downwind distance (m)	Chi/q	Dose in rem: Total dose autumn	External dose autumn	Inhalation dose autumn	Ingestion dose autumn
Stability class	F	70710	6.20E-06	6.97E+00	2.14E-02	1.58E+00	5.39E+00
Controling Organ	Lung		**Pathway**	Ingestion	**Nuclide**	I-125	